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The implications of space science terminology and concepts for elementary science teaching are explored. Twenty-two concepts were identified which elementary and junior high school teachers were invited to introduce in their teaching. Booklets explaining the concepts were distributed together with report forms for teacher feedback. The numbers of teachers who used each concept are reported; also the numbers of students and grade levels involved. Summarizing the teacher feedback, the commission reports that teachers tended to introduce space science concepts in conjunction with topics normally taught without altering their regular sequence or methods of instruction. Teachers requested the provision of audio-visual aids. Recommendations are made for improvements to the program. Copies of instructions to the teachers, explanations of the concepts, and the "Professional Report" (Feedback) form are included in appendices. (EB)

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Space Science Education: An Experimental Study

Report of the Study Commission on Space Science Education

by
Raymond Vick, M.Ed.
Research Assistant

U.S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
OFFICE OF EDUCATION

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SPACE SCIENCE EDUCATION: AN EXPERIMENTAL STUDY

REPORT OF THE STUDY COMMISSION ON SPACE SCIENCE EDUCATION

by

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Research Assistant

GULF SCHOOL RESEARCH DEVELOPMENT ASSOCIATION
3801 Cullen Boulevard Houston, Texas 77004

1969

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(1966 - 1968)

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FOREWORD

Within the past few years man's knowledge of space has increased to the point where the public school science curriculum must include a study of space if the needs and interests of modern youth are to be served. The scarcity of appropriate instructional materials has been one of the major problems in expanding instruction in space science, and has retarded the efforts of many teachers desiring to add space science units or courses to their currculum.

As a result of this need, the Gulf School Research Development Association established a Study Commission on Space Science Education which conducted a research study on space science education. This publication by Mr. Raymond Vick, Research Assistant, presents the report of the study.

The researcher concludes that adding space-related materials to the instructional program does not necessarily imply that major curriculum changes must be made. Space-related materials can be built into any curriculum, new or old, modern or traditional. Administrators then have the responsibility of encouraging and assisting their teachers to add space instruction to their science program. It is hoped that this research study will prove helpful to administrators and teachers in the further development of their space science education programs.

V. J. Kennedy
Executive Secretary

February 1969

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INTRODUCTION

The Commission on Space Science Education was established October 28, 1965 by the Planning Assembly of GUSREDA in response to certain needs of member school districts. These needs were: (1) distribution or dissemination of materials, (2) communication among and within school systems, (3) emphasis for curriculum purposes on evaluation, and (4) study of evaluation materials.

The commission was especially interested in an analysis of space science content in current textbooks used in member districts and in processing and integrating into existing courses of study recent space science data. In general, the commission sought an approach based on concept analysis with contribution from space science research applicable to the elementary school.

PROBLEM

The space age has produced new terminology and concepts which may have implications for teaching science in the elementary school. The Commission on Space Science Education was formed to explore these implications. The question of how "spin-off" from the space science efforts of The National Aeronautics and Space Administration could best be utilized in teaching elementary science was the basic consideration of the commission.

PROCEDURE

The committee selected five space science concepts for field testing as a pilot project. A "Professional Report" for reporting the results was prepared for the participating classroom teachers. They were to record lesson planning, presentation, student experience, and recommendations. The "feedback" from the classroom teachers was considered vital by the commission.

A review of the findings of the pilot space science concepts projected encouraged the commission to have a professional panel select additional space concepts for field testing and repeat the professional report. The 1967 Administration and Supervision Workshop at the University of Houston (37 participants) constituted the professional panel which isolated 22 space science concepts from Educational Briefs of NASA.

Member districts were requested to invite some of their elementary and junior high teachers to make classroom application of these selected concepts. A total of 103 booklets of 22 space science concepts were distributed to member schools. "Professional Reports" were distributed with the booklets along with an instruction letter.

OBJECTIVES

Specific objectives of the project were:

1. To introduce selected concepts to children in grades 4-8.

2. To obtain a description of methods and materials developed by the teacher for introducing the concepts.

3. To obtain factual knowledge concerning the children's reaction to the concepts.

4. To determine student behavior resulting from the lesson in terms of continued inquiry.

5. To determine if selected concepts fit a need in the science curriculum.

6. To determine if selected concepts are useful in their present form.

The tables which follow present the findings relative to the study in data form. Table I, page 3, shows the total number of districts, concepts, teachers, and students involved in the space science project. Table II, page 4, lists specific concept usage by grade level, and Table III, page 5, presents student-teacher usage of each concept by grade level.

TABLE I

TOTAL DISTRICTS, CONCEPTS, TEACHERS AND
STUDENTS INVOLVED IN SPACE SCIENCE CONCEPT PROJECT

Districts	Number of Concepts Used	Total Teachers Involved	Students Exposed by Grades to Concept 4	5	6	7	8	9	Combination 4-5-6	Total Students Involved
Aldine	13	6			215		437	66		718
Anahuac	2	1	22							22
Bay City	8	3				80	411			491
Brazosport	9	3		112			135			247
Columbia-Brazoria**										
Crosby**										
Dickinson**										
Katy**										
Lamar Consolidated	10	6	57	25	270					352
La Marque	7	2			285				206	491
Nederland**										
Pearland	2	1					90			90
Spring Branch	14	8	2660*		647		863			4170*
Texas City**										
TOTALS:		30	2739*	137	1417	80	1936	66	206	6581*

*Includes television presentation to 2660 4th graders.
**No reply.

TABLE II

SPECIFIC CONCEPT USAGE BY GRADE LEVEL

Concept	NASA Number	Number of Times Concept Used by Grade 4	5	6	7	8	9	Combination 4-5-6	Times Concepts Used
1. Directional Changes Produced by Gravity	4001	1				3	1		5
2. Synchronous Orbit	4002			2		3			5
3. Energy Dissipation	4003								
4. Absorbing or Ablating Energy	4004	3	1			3			7
5. Nuclear Spin	3003.2					2			2
6. Food Preparation by Freeze Dehydration	1003	5	2	4	1	3		1	16
7. Osteoporosis	1001			1					1
8. Hydrostatic Pressure	1004.1			2					2
9. Body Mechanism Assisting in Blood Flow	1004.2			5					5
10. Motion of the Lunar Orbit Plane	2002					4			4
11. Ecliptic Plane	2002	1				2	1		4
12. Changes of the Moon's Inclination	2003					5			5
13. Lunar Coordinates	2004								
14. Specific Impulse	3001								
15. Lithium Hydroxide Removal of Carbon Dioxide	3002	1				1		1	3
16. Weightlessness	4001.2	3		5		1		1	10
17. Energy of Orbiting Spacecraft	4003	1				3		1	5
18. Atmosphere Drag Braking	4004	1		2		3		1	7
19. Perturbation	2002					1			1
20. Elliptical Orbit of Moon	2001	1	1	2		5			9
21. Orthostatic Hypotension	1004.1	1		3	1				5
22. Barycenter	2001			1		2			3
TOTALS:		18	4	27	2	41	2	5	99*

*Some replies contained more than one concept.

TABLE III

STUDENT-TEACHER USAGE BY CONCEPT

Concept	NASA Number	Number of Teachers Using Concept	Number of Students by Grade 4	5	6	7	8	9	Combination 4-5-6	Total Students Involved
1. Directional Changes Produced by Gravity	4001	5	2660*				366	66		3092*
2. Synchronous Orbit	4002	5			258		236			494
3. Energy Dissipation	4003									
4. Absorbing or Ablating Energy	4004	7	2710*	25			436			3171*
5. Nuclear Spin	3003.2	2					69			69
6. Food Preparation by Freeze Dehydration	1003	16	2839*	81	728		563		206	4417*
7. Osteoporosis	1001	2			61		60			121
8. Hydrostatic Pressure	1004.1	2			96					96
9. Body Mechanism Assisting in Blood Flow	1004.2	5			802					802
10. Motion of the Lunar Orbit Plane	2002	4					507			507
11. Ecliptic Plane	2002	4	28				418			446
12. Changes of the Moon's Inclination	2003	5					424			424
13. Lunar Coordinates	2004									
14. Specific Impulse	3001									
15. Lithium Hydroxide Removal of Carbon Dioxide	3002	3	29				180		206	415
16. Weightlessness	4001.2	10	2717*		918		121		206	3962*
17. Energy of Orbiting Spacecraft	4003	6	2660*		90		251		206	3207*
18. Atmospheric Drag Braking	4004	6	28		150		208		206	592
19. Perturbation	2002	1					35			35
20. Elliptical Orbit of Moon	2001	9	28	31	300	60	595			1014
21. Orthostatic Hypotension	1004.1	5	29		647	80				756
22. Barycenter	2001	3			180		253			433
TOTALS:			13728*	137	4230	140	4722	66	1030	24053*

*Includes television presentation to 2660 4th graders.

SUMMARY

Analysis of "feedback" data from participating teachers reported in the "Professional Reports" supports the following conclusions:

1. Teachers tended to introduce space science material not in the text in conjunction with regular planned units or lessons. Supporting this conclusion are such statements as: "This concept was introduced with Chapter 27, 'Our World'." "I introduced the concepts as a follow-up to the unit in the text on man's circulation." "We used the school textbook a lot." "I introduced three concepts during the time of my scheduled unit."

2. Teachers were inclined to retain the regular sequence of instruction in introducing space science material. Supporting this conclusion are the following statements from "Professional Reports": "Brief lecture following series of NASA films used in connection with teaching unit." "Concept introduced in unit on 'Earth Chemistry'." "This concept was introduced in relation to a chapter entitled 'Space Travel'."

3. Practical considerations outweighed experimental use of the space science materials. Supporting this conclusion are statements as follow: "Concept would be more suitable had I used it earlier in the year." "Next time I would attempt to demonstrate the chemical reaction." "We read about weightlessness in class and discussed it." "The book discussed the necessity of food supplies for space." "We studied the chart illustrated in the 'Educational Brief'."

4. Most of the responses indicated teachers wanted more audiovisual aids. Supporting this conclusion are the following representative statements: " A good documentary film could be used." "A series of colored lithographs would be helpful." "A transparency might prove helpful." "Some visual aids would be helpful." "Visual aids are good and recommended." "I would use audiovisual aids." "I would not attempt such again without more material to work with."

RECOMMENDATIONS

On the basis of information gained from developing and expediting this experimental study on space science education, the following general recommendations are made, with anticipation of continued interest in the original implications of the investigation to member districts. The recommendations are:

1. With reference to the educational utilization of "spin-off" from the space science efforts, it is recommended that a glossary of terms to meet the vocabulary needs of teachers and pupils at a particular grade level of use accompany each concept.

2. It is further recommended that individual teachers be encouraged to make experimental use of the space science concepts presented in this study.

3. School districts interested in developing special educational programs for high academic achievers should give consideration to the adaptation of these space science concepts to such programs.

4. Careful consideration should be given to the current educational concept of "structure" as it relates to adaptation of these space science concepts to classroom use.

5. Visual aids should be developed for use with each of the concepts.

6. Finally, continual evaluation of the adaptability and application of space science "spin-off" to classroom learning situations is recommended.

APPENDICES

APPENDIX A

December 14, 1967

INSTRUCTIONS

The purpose of this project of your Study Commission on Space Science Education is to field test several science concepts selected from Educational Briefs published by the National Aeronautics and Space Administration, Manned Spacecraft Center in Houston, Texas.

The space age has produced new terminology and concepts which may have implications for teaching science in grades 4-8. A panel of teachers isolated the attached 22 space science concepts from NASA publications. More detailed explanation may be obtained in the respective Educational Briefs and other current literature. We think you and your classes will find this "spin out" of the space science efforts of NASA to be informative.

Will you be so kind as to introduce one or more of these space science concepts in your science teaching curriculum during the months of January and February, 1968? Please complete a copy of the attached professional report form for each concept tried out and return it to the space science study commission representative in your school district (or to GUSREDA) by March, 1968.

Your professional application and experience in teaching specific space science concepts is the essential outcome of the project.

Raymond Vick
Research Assistant

Dr. Jody Stevens
Research Director (1967-68)
GUSREDA

APPENDIX B

SPACE SCIENCE CONCEPTS

1. Directional Changes Produced by Gravity #4001
2. Synchronous Orbit #4002
3. Energy Dissipation #4003
4. Absorbing or Ablating Energy #4004
5. Nuclear Spin #3003.2
6. Food Preparation by Freeze Dehydration #1003
7. Osteoporosis #1001
8. Hydrostatic Pressure #1004.1
9. Body Mechanisms Assisting in Blood Flow #1004.2
10. Motion of the Lunar Orbit Plane #2002
11. Ecliptic Plane #2002
12. Changes of the Moon's Inclination #2003
13. Lunar Coordinates #2004
14. Specific Impulse #3001
15. Lithium Hydroxide Removal of Carbon Dioxide in Spacecraft #3002
16. Weightlessness #4001.2
17. Energy of Orbiting Spacecraft #4003
18. Atmospheric Drag Braking #4004
19. Perturbation #2002
20. Elliptical Orbit of Moon #2001
21. Orthostatic Hypotension #1004.1
22. Barycenter #2001

Educational Brief #4001

Directional Changes Produced by Gravity

1. Tangential velocity is imparted to a satellite or spacecraft when it is launched into orbit. The Earth's gravitational force continuously changes the direction of this velocity so that the vehicle moves around the Earth. The space vehicle's velocity and orbital radius must be such that the gravitational pull at that radius will change the direction of motion to an orbital path, which does not intersect the atmosphere. When this occurs, the vehicle is said to be in a stable orbit. (No. 4 in Brief #4001)

2. Gravity produces the same change of direction on all objects within a spacecraft as it does on the spacecraft itself. Since all objects in the spacecraft experience the same velocity and direction change as the spacecraft, they are motionless relative to each other and produce no push or pull on one another. An object placed in a given position in a spacecraft would remain in that position, apparently suspended. (No. 5 in Brief #4001)

Educational Brief #4002

Synchronous Orbit

1. A circular orbit having a period equal to the period of the Earth's rotation (24 hours) is called a synchronous orbit. A satellite in an equatorial orbit of this type would appear to remain stationary to an Earth observer. (No. 5 in Brief #4002)

2. Satellites at an altitude below the synchronous level have orbital periods less than the period of rotation of the Earth and rise in the west and set in the east. Satellites at an altitude above the synchronous orbit level have orbital periods greater than the period of rotation of the Earth and rise in the east and set in the west. These satellites appear to travel in opposite directions to an Earth observer. (No. 6 in Brief #4002)

Educational Brief #4003

Energy Dissipation

Potential Energy

P. E. = wh

= (1 lb.) (528,000 ft.)

= 528,000 ft-lbs.

Kinetic Energy

K. E. = $\frac{1}{2}mv^2$

= $(\frac{1}{2})$ $(\frac{1 \text{ lb.}}{32 \text{ ft/sec}^2})$ $(25{,}000 \text{ ft/sec})^2$

= 9,765,000 ft-lbs.

where: w = weight v = velocity g = acceleration of gravity (32 ft/sec^2)

m = mass = $\frac{w}{g}$ h = altitude

The sum of these energies is 10,000,000 ft-lbs. in round numbers. The following table shows the energy of vaporization of a few common materials.

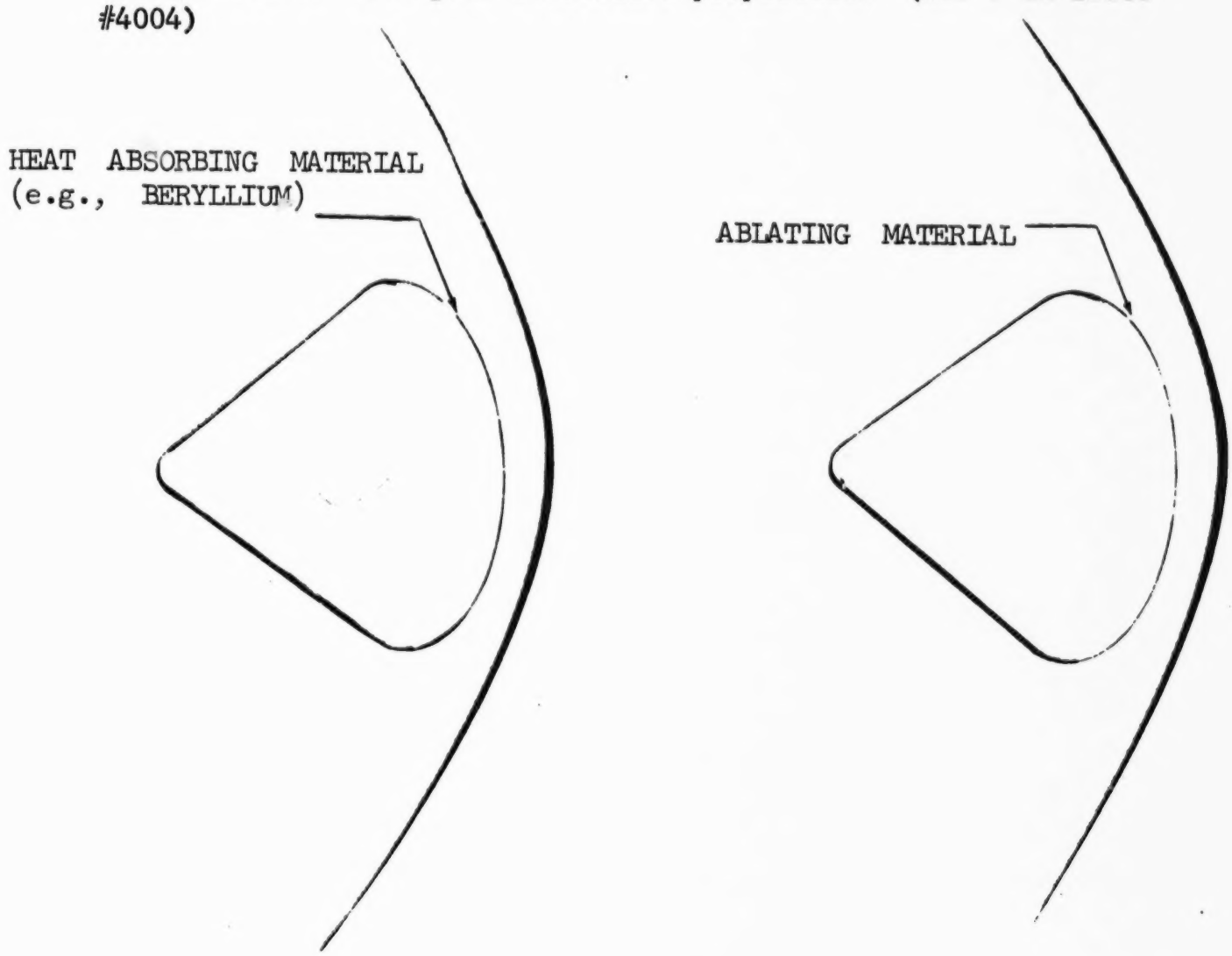
To Completely Vaporize:	Energy Required (ft-lbs/lb)
Aluminum	3,500,000
Steel	2,100,000
Titanium	3,100,000
Tungsten	1,400,000
Water	800,000

1. In accordance with the Law of Conservation of Energy, the energy of the spacecraft with respect to the Earth must somehow be dissipated in order for it to return to the Earth. Two methods that may be employed are rocket braking and atmospheric drag braking. (No. 5 in Brief #4003)

Educational Brief #4004

Absorbing or Ablating Energy

1. The energy which does reach the face of the spacecraft must, therefore, be absorbed or dissipated safely. This can be accomplished (a) by providing a heat shield of a material of high specific heat, such as beryllium, which can absorb the heat, or (b) by providing a heat shield of an expendable material which is ablated (carried away) in the process of protecting the spacecraft. Certain plastics can absorb heat in this manner by vaporizing, melting or charring, while retarding the flow of heat into the spacecraft with good insulative properties. (No. 7 in Brief #4004)



Teaching Suggesting: Compare the heating effects of a blunt shape which produces a large shock wave to that of a slender, streamlined shape. Relate this to how some meteorites reach the Earth's surface without vaporizing completely.

Educational Brief #3003.2

Nuclear Spin

1. "Nuclear spin" can be in either direction. The combination of two hydrogen atoms with similar or opposite "nuclear spin" dictates whether ortho-hydrogen molecules or para-hydrogen molecules are formed. Molecules of ortho-hydrogen are produced when atoms with similar or parallel "nuclear spins" combine, e.g., atom (a) combines with atom (c) or atom (b) combines with atom (d) as illustrated in Figure Three. (No. 5 in Brief #3003.2)

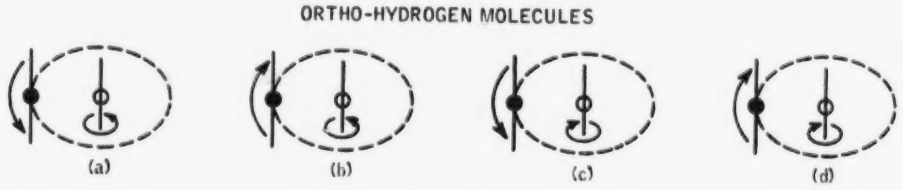


Figure 3

2. Molecules of para-hydrogen are formed when two atoms with opposite or antiparallel "nuclear spin" combine, e.g.,atom (a) combines with atom (d) or atom (b) combines with atom (c) as shown in Figure Four. (No. 6 in Brief #3003.2)

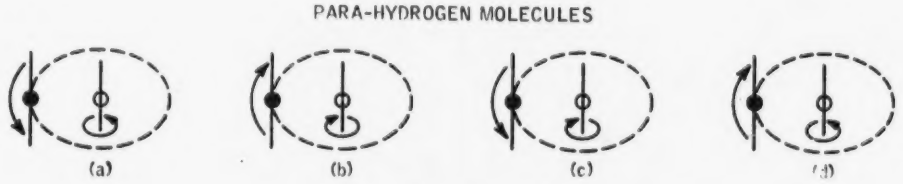


Figure 4

Educational Brief #1003

Food Preparation by Freeze Dehydration

1. A number of the menu items will be freeze-dehydrated foods, commonly called freeze-dried foods. They are preapred by placing frozen foods, raw or cooked, in chambers from which air is evacuated. Under vacuum, small amounts of heat are applied to the frozen product; thus water is removed from the food by subliming* the ice in the food. This technique produces a flavorful product which is lightweight and retains practically all its nutritious properties. (No. 2 in Brief #1003)

*The process of changing from the solid state directly to the gaseous state.

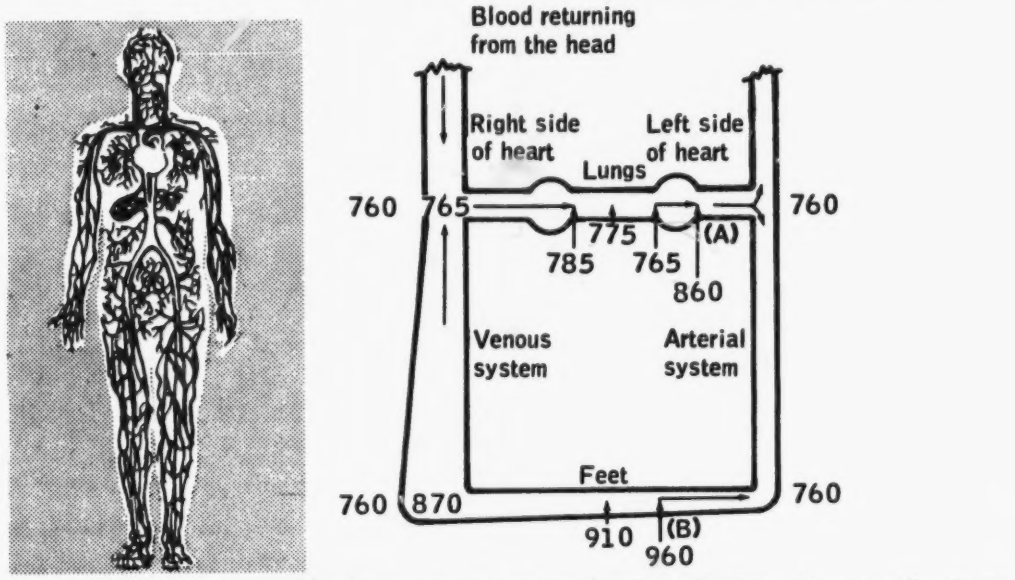
Educational Brief #1001

Osteoporosis

1. To establish the rate and amount of calcium lost to the body while in space, the astronauts on Gemini flights will maintain a 0.8 to 1.0 gram/day calcium diet for two weeks prior to flight, and for two weeks after landing. Careful analysis of dietary intake and output will be maintained. Two 5 cc blood samples will be analyzed before and after each mission, with a week between each sampling. Urine samples (100 cc each) will be analyzed for phosphorus, nitrogen, calcium, and other minerals during the test period. (No. 5 in Brief #1001)

Educational Brief #1004.1

Hydrostatic Pressure



Blood pressures at various levels at IG-force when standing in air

1. The schematic above shows a hypothetical representation of hydrostatic pressure levels at various points in the cardiovascular system of a normal individual standing in air at 1 gravity force. Gravity produces a hydrostatic pressure on the blood system just as it does on a column of water. Gravity affects the circulatory system with respect to the position of the body relative to the direction of the applied force. (No. 2 in Brief #1004.1)

   The influence of 1 g-force, acting upon the erect body is parallel to the spine and directed downward. Thus, a greater pressure gradient is produced upon the blood in the lower portion of the body, legs and feet, than in the head.

Educational Brief #1004.2

Body Mechanisms Assisting in Blood Flow

1. Normal body mechanisms assist the blood flow to the heart and brain upon standing. The body functions listed below aid circulation through the venous system in a 1 g condition.

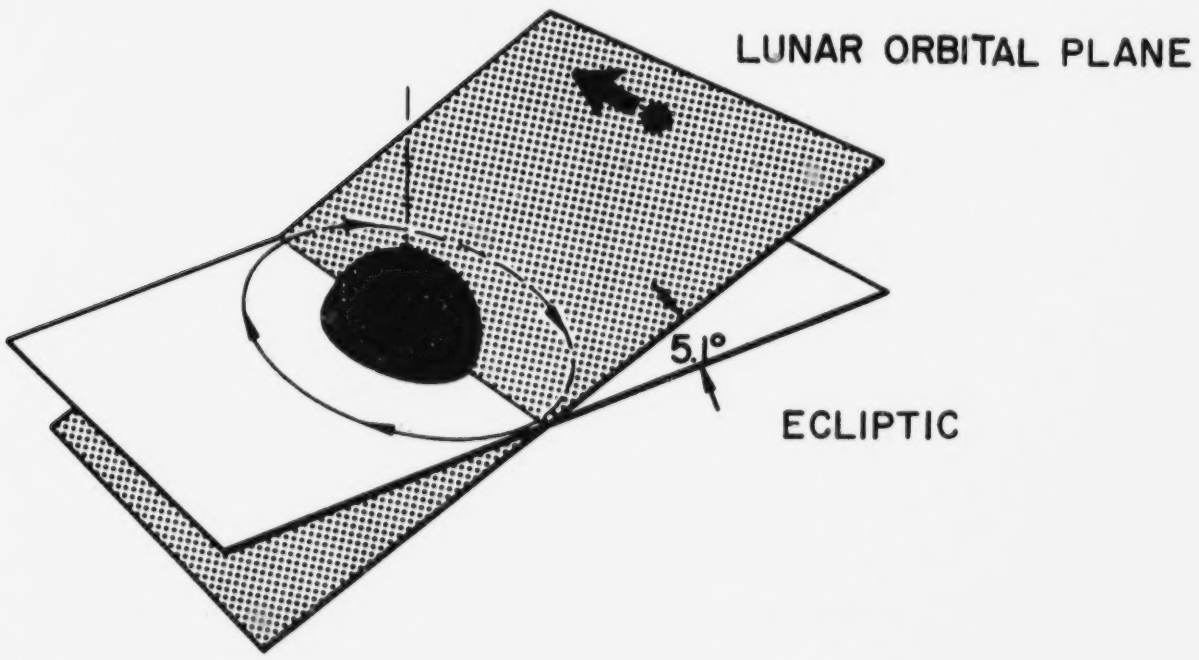
   a. Massaging of the veins by muscular contraction "milks" the blood from the extremities toward the central venous system.

   b. One-way valves within the veins trapping the flow of blood encourage the flow to the deep venous circulation.

   c. Smooth muscle fibers in the vein walls contract upon stimulation of nerves within the vein walls, decreasing the caliber of the veins. This reduces the space in the lower portion of the body for blood pooling, thus forcing a greater volume toward the heart. (No. 2 in Brief #1004.2)

Educational Brief #2002

Motion of the Lunar Orbit Plane



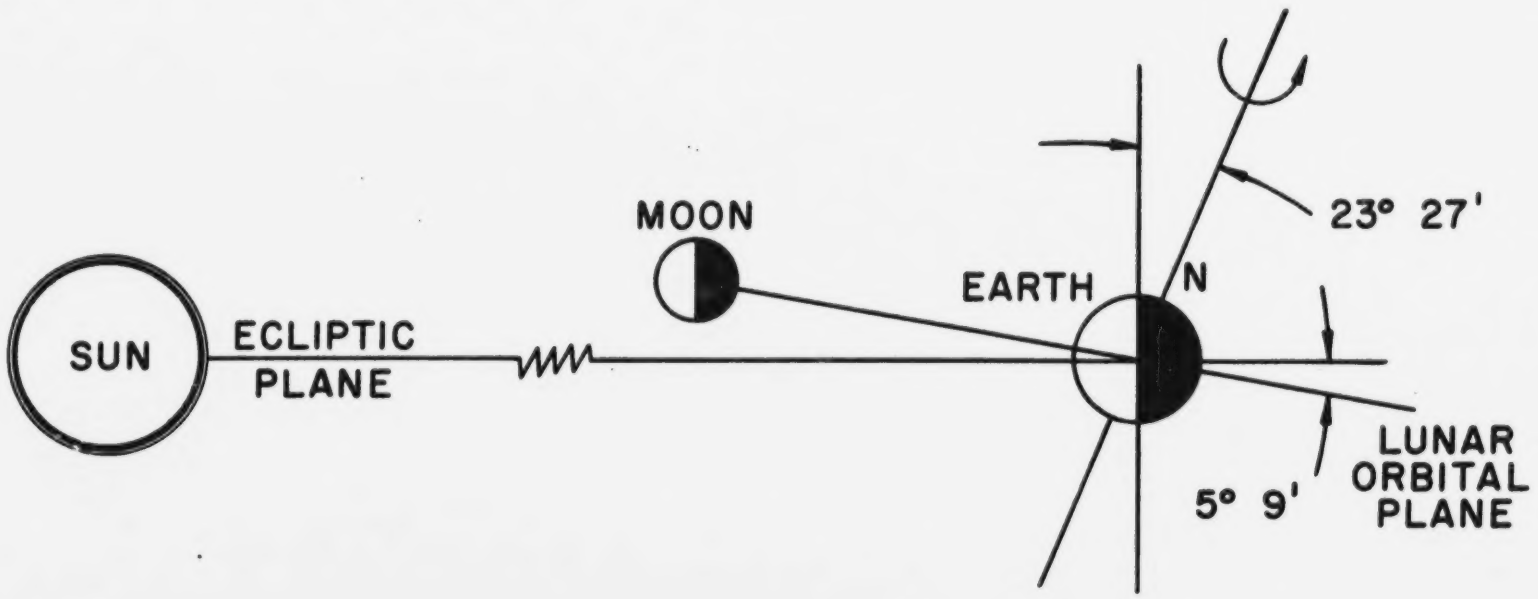
1. The intersection of the lunar orbit plane with the ecliptic plane produces a line known as the line of nodes.

2. Due to the perturbation produced by the Sun, the lunar orbit plane rotates about the ecliptic axis. This causes the line of nodes to revolve, completing one full revolution in 18.6 years at a rate of 19.4 degrees annually.

3. The direction of rotation of the line of nodes is in a retrograde sense or motion in a clockwise direction with respect to the Earth's orbit.

Educational Brief #2002

Ecliptic Plane



1. An orientation of the Earth-Moon system to the Sun is made in the diagram above as viewed from within the Earth orbital plane.

2. The orbital plane described by the Earth about the Sun is called the ecliptic plane.

Educational Brief #2003

Changes of the Moon's Inclination

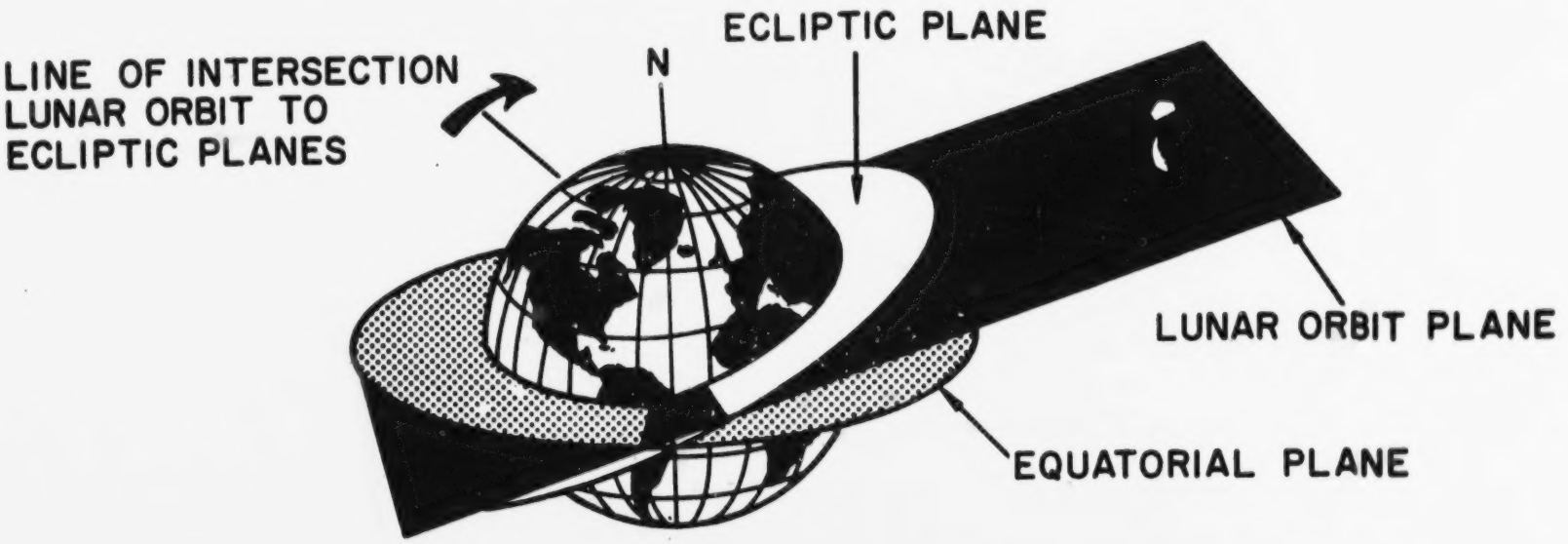


ILLUSTRATION OF LUNAR ORBIT PLANE IN YEAR 1960
INCLINATION ANGLE (i)= 18.5°

ILLUSTRATION OF LUNAR ORBIT PLANE IN YEAR 1968
INCLINATION ANGLE (i)= 28°

Educational Brief #2004

Lunar Coordinates

Orientation - Cardinal directions have been established to conform with cartographic tradition, north to top and east to right, rather than astronomical convention. This orientation positions the Moon in its true relationship to the Earth. The visible disk shown is 180 degrees at mean libration*.

* The apparent oscillation of a body.

Educational Brief #3001

Specific Impulse

1. The reaction of a chemical fuel with an oxidizer releases a chemical energy. The calculation of this chemical energy can be used to determine the propulsive efficiency for rocket propellants. Propulsive efficiency or specific impluse* calculation depends upon the total energy released by the burning fuel.

* Specific impulse (I_{sp}) is defined as that force or thrust produced from burning one pound of a chemical propellant per second. Specific impulse is proportional to the square root of the heat made available by the mass reaction and may be calculated by:

$$I_{sp} \approx \sqrt{\frac{2J\Delta H}{\overline{M}}}$$

J = mechanical equivalent of heat, 778 ft-lb/btu
ΔH = heat per mole released during expansion
$\overline{M}$ = average molecular weight of the gases, lb/mole

Educational Brief #3002

Lithium Hydroxide Removal of Carbon Dioxide in Spacecraft

1. Lithium hydroxide absorbs carbon dioxide readily in the presence of water according to the following chemical reaction:

$$2\ LiOH + CO_2 \longrightarrow Li_2CO_3 + H_2O + Heat$$

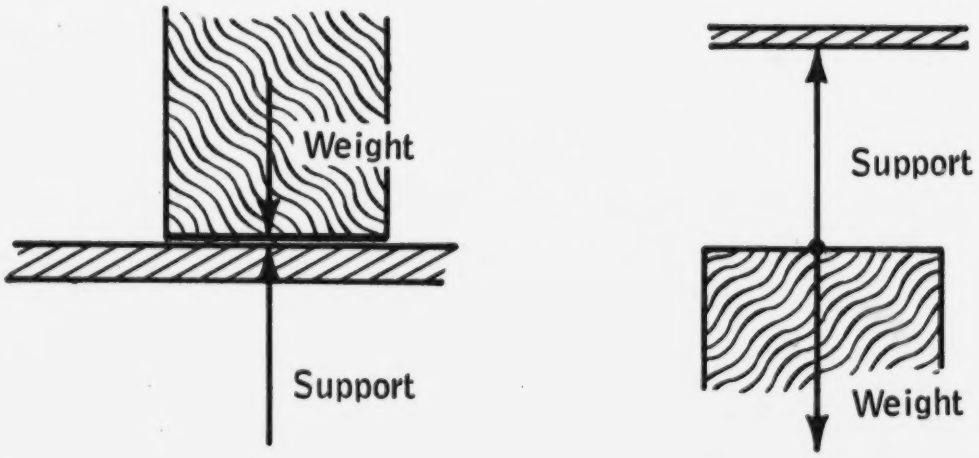
This reaction is exothermic, producing $\sim$ 1060 BTU/lb of CO_2 absorbed which must be dissipated from the spacecraft. (No. 3 in Brief #3002)

Educational Brief #4001.2

Weightlessness

1. Weight can be defined as the measure of gravitational force exerted on an object. The weight of an object is dependent on the mass of the object and acceleration produced by the force of gravity. Weight (w) is the product of the mass of an object (m) and gravitational acceleration (g). Expressed mathematically: $w = mg$

When a body is supported by some physical means such as a chair, the Earth's surface, or aerodynamic lift, the body is supported by a force equal to the weight of the object. The forces acting at the interface of the body and the support are equal and opposite as indicated in Figure 1 below.

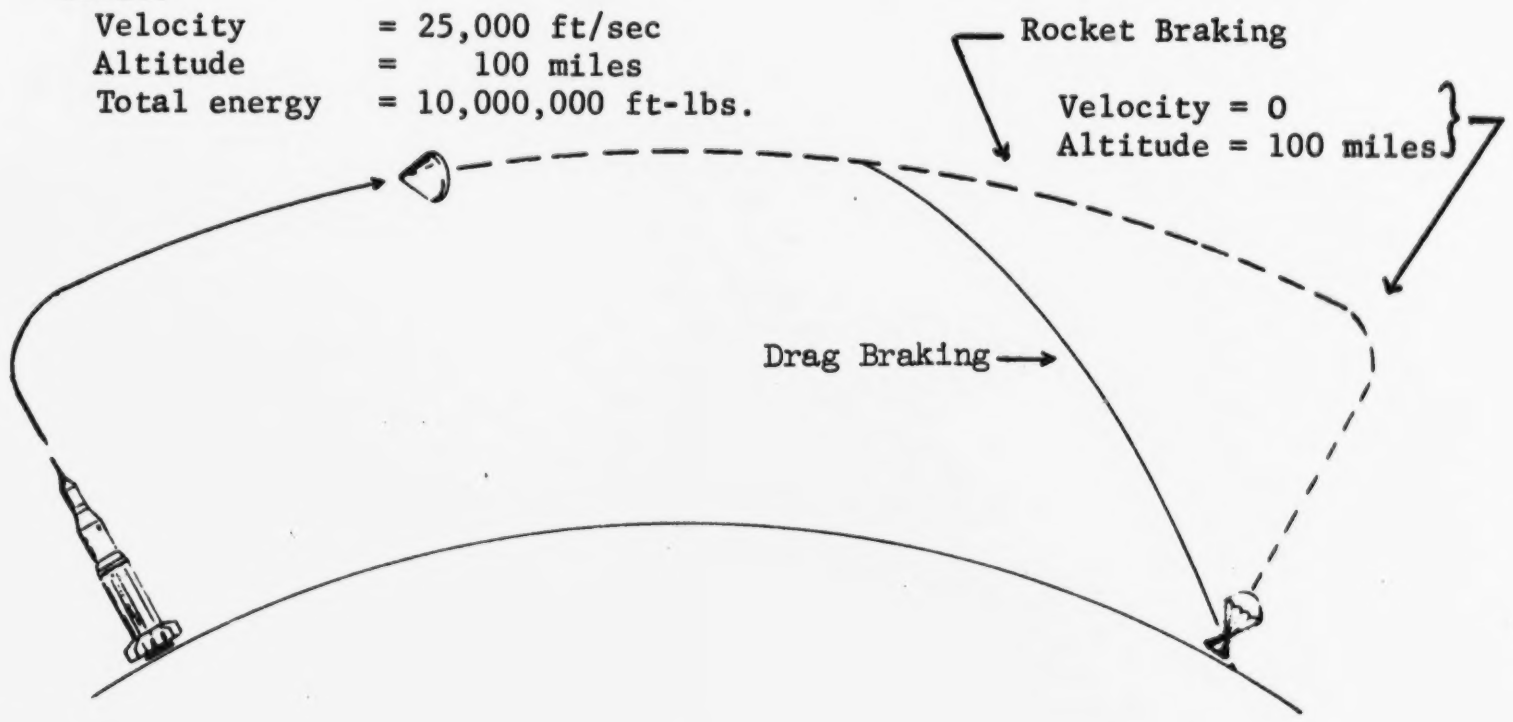


The condition of "weightlessness" or relative weightlessness is produced when there is motion in such a manner than no mechanical means of support is required to overcome gravitational force.

Educational Brief #4003

Energy of Orbiting Spacecraft

1. The following sketch represents conditions of a spacecraft (with respect to the Earth) before launch, during orbit and after landing.



(No. 2 in Brief #4003)

2. The potential energy and kinetic energy of the spacecraft before launch and after landing are zero because the altitude and velocity respectively are zero. (No. 3 in Brief #4003)

3. The total potential and kinetic energy of a spacecraft orbiting at 100 miles altitude is approximately 10,000,000 ft-lbs. per pound. This energy is imparted to the spacecraft as it is lifted to altitude and accelerated to orbital velocity. (No. 4 in Brief No. 4003)

Educational Brief #4004

Atmospheric Drag Braking

1. A "shock wave" is caused whenever a body travels through a medium, i.e., atmosphere or water, at a speed greater than the speed of sound in the medium. Sound is a pressure wave. A body traveling faster than the speed of sound in a medium causes a buildup into what is called a "shock wave." (No. 2 in Brief #4004)

2. The shock wave produced by a spacecraft causes a release of energy to the air at a rate so great that the air is heated to incandescence. The light thus produced was reported to be visible as far as 35 miles away in reentry from Mercury flights. (No. 4 in Brief #4004)

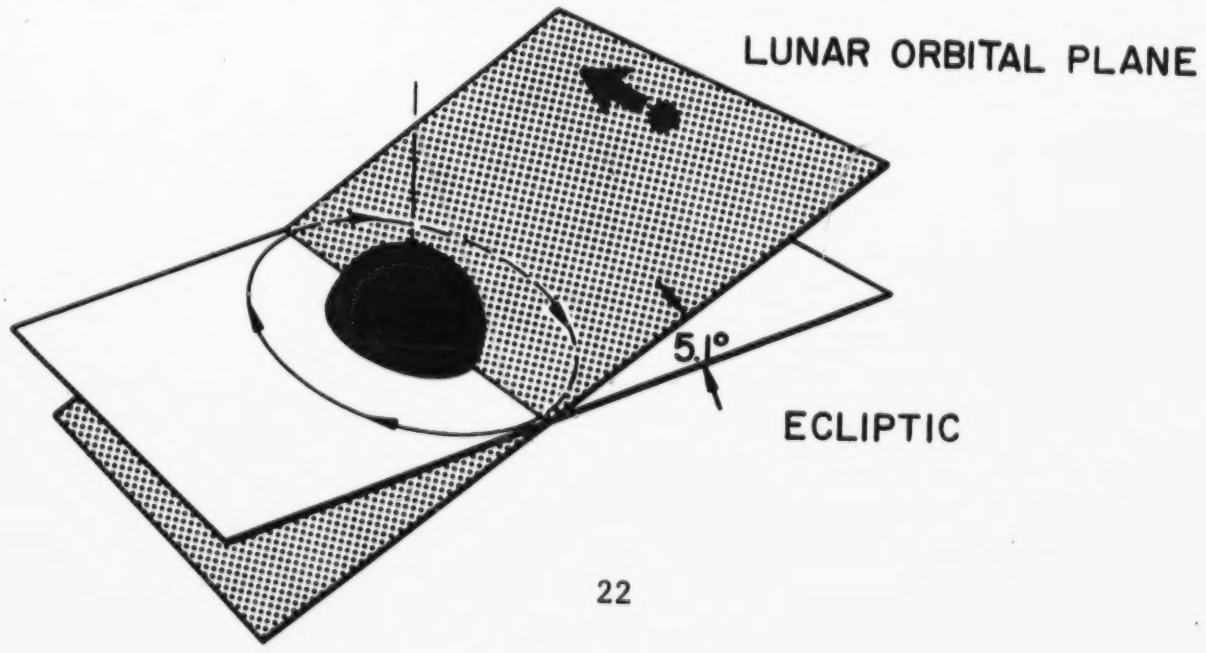
3. Most of this energy, 98 to 99%, is discharged harmlessly around the spacecraft into the atmosphere by the air flow. Only 1 to 2% of the orbital energy or less, actually reaches the blunt face of the spacecraft. (No. 5 in Brief #4004)

Educational Brief #2002

Perturbation

Perturbations - Deviations of a mass from the normal path of motion it would experience if it were one of two point masses which move subject only to their mutual grafitational attraction. These deviations are produced by forces external to the two body system itself.

MOTION OF THE LUNAR ORBIT PLANE



1. The intersection of the lunar orbit plane with the ecliptic plane produces a line known as the line of nodes.

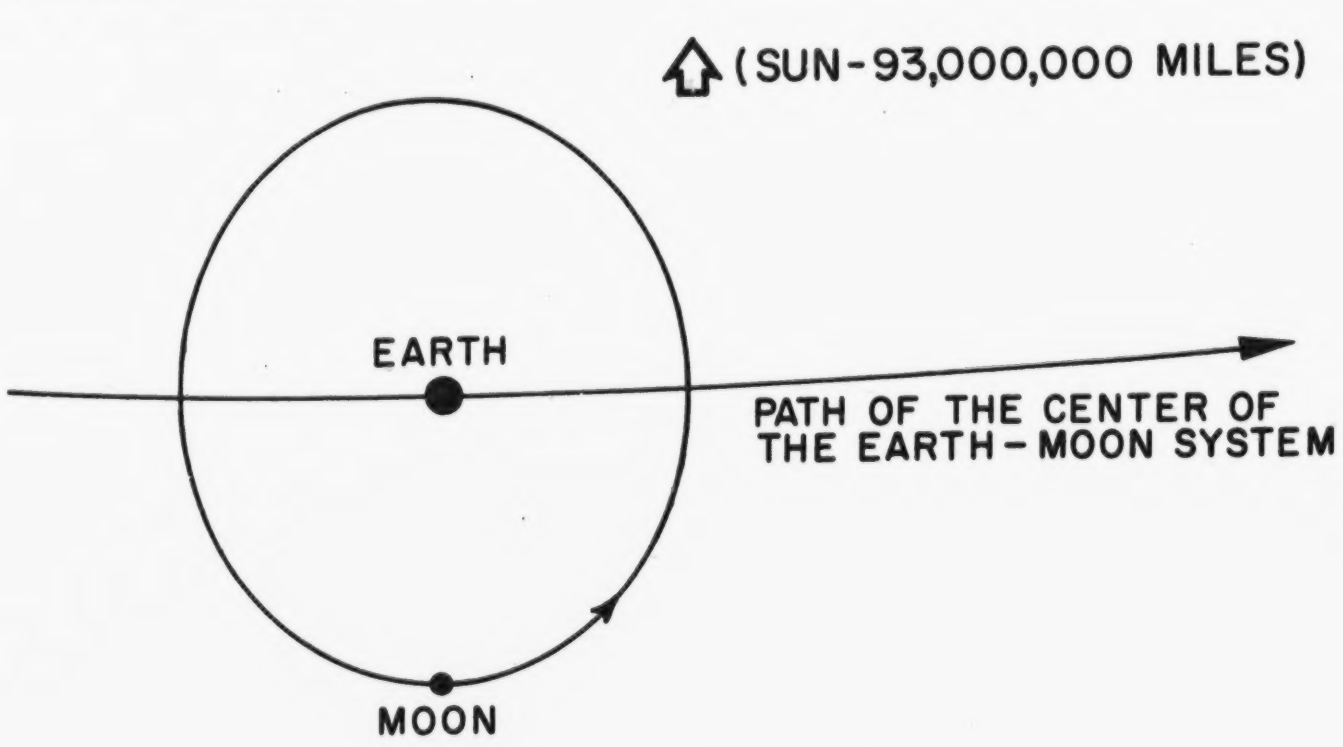
2. Due to the perturbation * produced by the Sun, the lunar orbit plane rotates about the ecliptic axis. This causes the line of nodes to revolve, completing one full revolution in 18.6 years or at a rate of 19.4 degrees annually.

3. The direction of rotation of the line of nodes is in a retrograde sense or motion in a clockwise direction with respect to the Earth's orbit.

Educational Brief #2001

Elliptical Orbit of Moon

ORBIT OF THE MOON



SELENOLOGY: (Selene - Greek for the Moon) The branch of astronomy dealing with the Moon.

1. The Moon moves in an orbit about the center of the Earth-Moon system describing what is called the lunar orbit plane.

2. The orbit of the Moon is elliptical but it very nearly approaches a circle.

   a. The farthermost point from the Earth, or apogee, is 252,700 miles.

   b. The nearest point to the Earth, or perigee, is 221,000 miles.

   c. The average distance from the Earth is 238,900 miles or 60.268 times the Earth's equatorial radius.

3. The time required for the Moon to complete one revolution is 27 days 7 hours 43 minutes 11 seconds.

4. The revolution of the Moon in its orbit about the Earth is in the same direction as that of the Earth about the Sun (counter clockwise).

Educational Brief #1004.1

Orthostatic Hypotension

1. Man's reactions to weightlessness have been considered as a possible limiting factor in manned space flight. The body systems which are most frequently represented as potential problem areas are the cardiovascular, musculoskeletal and the vestibular. Some of the last of the Mercury astronauts to fly as well as several Russian cosmonauts exhibited a drop in blood pressure and increase in heart rate on assuming the standing position immediately after landing. This condition called "orthostatic hypotension" sometimes results in fainting, indicating a temporary collapse of the circulatory system.

   There is serious concern that the space crewmen may become so susceptible to fainting that they will not survive the increased gravity forces during reentry into the Earth's atmosphere following extended space flights.

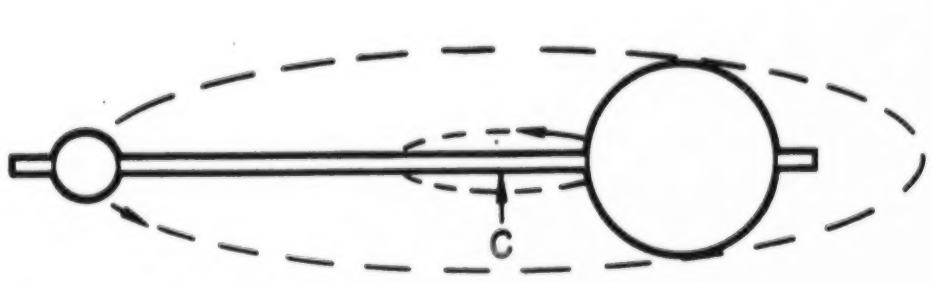
   Data from water immersion, bed rest studies, and "weightless" flight indicate that the control centers which maintain the blood flow tend to "forget" to function when returned to conditions of normal stress.

2. Upon standing, after water immersion or "weightless" flight, the flow of blood is redistributed with about 15% volume pooling in legs. Pooling lowers the normal hydrostatic pressure of the circulation blood and the flow to the head decreases. The diagram

on the right above, illustrates the increased volume of blood in the feet after changing from immersion tests to condition of 1 g. The heart increases the pulse rate in an attempt to restore the volume of blood to an equalized state shown by the illustration on the front page. Reduction of blood flow to the upper portions of the body and the brain cause the condition of postural hypotension or fainting. To compensate for the loss of blood, the brain increases the extraction of oxygen and nutrition from the decreased blood volume. Blood flow to the kidney decreases about 60% and vessels leading to the legs contract which decreases the blood flow in this area by 50%. Vessel contraction also aids by a pumping action which pushes the blood back to the heart. If these complex mechanisms do not operate, increased collection of blood in the leg vessels will occur. The blood flow to the brain further decreases and fainting may result. (No. 4 in Brief #1004.1)

Educational Brief #2001

Barycenter



1. The Earth and Moon are linked together by a force of mutual attraction called gravity; thus, behave as a single system.

2. This system could be compared to a dumbbell with a heavy weight on the end and a lighter weight on the other end (illustrated above). A dumbbell weighted in this manner would have a center of balance (or center of gravity) closer to the heavier end. For the unbalanced dumbbell to spin smoothly, it must be rotated about the center of balance.

3. The average position of the barycenter can be calculated from the relationship: $m_1 r_1 = m_2 r_2$

   r_1 = distance of the barycenter from the center of the Earth

   r_2 = distance of the barycenter from the center of the Moon

   m_1 = mass of the Earth (5.975×10^{24} kilograms)

   m_2 = mass of the Moon (7.3492×10^{22} kilograms)

   $r_1 + r_2$ = 238,900 miles

   (No. 7 in Brief #2001)

APPENDIX C

PROFESSIONAL REPORT
Return to: GULF SCHOOL RESEARCH DEVELOPMENT ASSOCIATION, INC.
3801 Cullen Boulevard Houston, Texas 77004

School District		Date
Title of Science Concept		
From Educational Brief No.	Grade	Number of Students
Report Prepared by (Teacher)		
LESSON PLAN: How did you introduce the concept? How did you present the material? Describe features of the lesson plan.		
STUDENT EXPERIENCES: Were the students interested, enthusiastic, or indifferent? Were you able to evoke student projects? Is the concept suitable for your situation? Identify specific student learning experiences.		
RECOMMENDATIONS: How would you present this concept next time? Are any facilities or visual aids required? Give your evaluation (use reverse side of page if necessary).		